Resource use in the World Economy 1960-2005
A preliminary assessment

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preface

- Now for the first time it is possible to present a comprehensive empirical assessment of global resource use, both materials and energy, on the basis of reasonably reliable and purely physical data and document longer time series.
- As far as materials are concerned, this is due to recent improvements in international statistics, such as: FAO (biomass), IEA (energy and fossil fuels), USGS (ores and minerals) and OECD (longer time series compiled by Maddison)
- as well as intensive efforts from the part of research institutions, in particular: The National Institute for Environmental Studies (NIES), Japan, the Sustainable Europe Institute (SERI), The Social Ecology Institute and the Wuppertal Institute.
- Several of these efforts were supported by EU FP5 und FP6 projects (such as MOSUS and MATISSE), but also by various national science funds
- Most of the data shown are novel, under publication, and should not (yet) be disclosed to third parties.

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Outline

The big picture: levels and dynamics of energy and materials use worldwide

1. Metabolic scale
2. Metabolic rate
3. Decoupling

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1. Metabolic scale

***Definition**: metabolic scale is the size of the overall annual material (DMC) or primary energy input (TPES, DEC) of a socio-economic system according to established standards of MEFA analysis.*

The metabolic scale of the world economy has been steadily increasing:

- From 20 billion tons in 1960 to over 60 bio t in 2005 (DE, materials extracted; on the global level = DMC)
- From 120 EJ primary energy in 1960 to 440 EJ in 2004 (TPES, biomass excluded)

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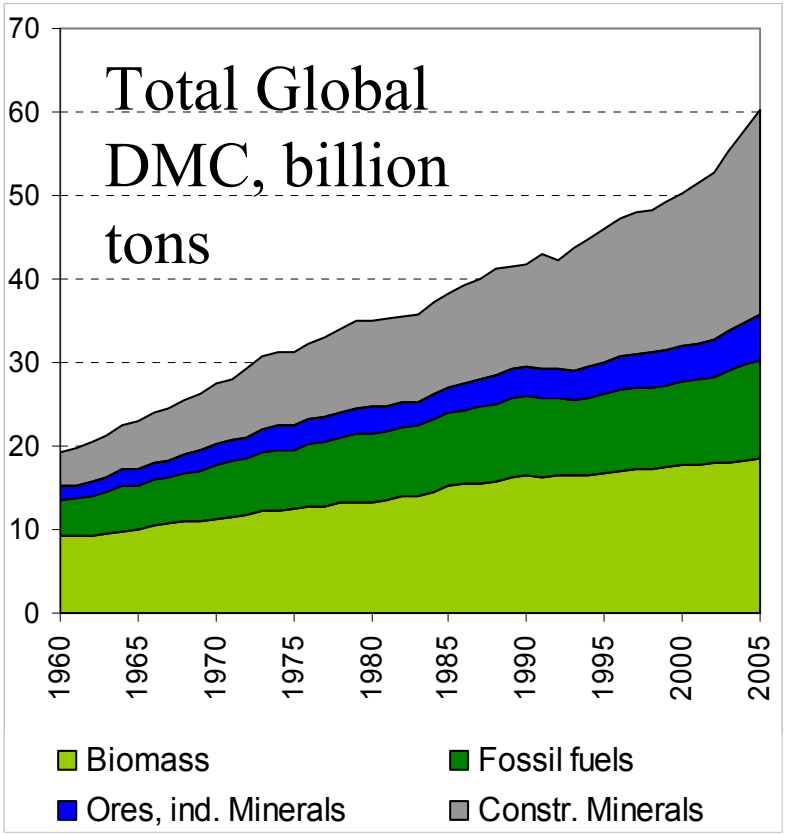
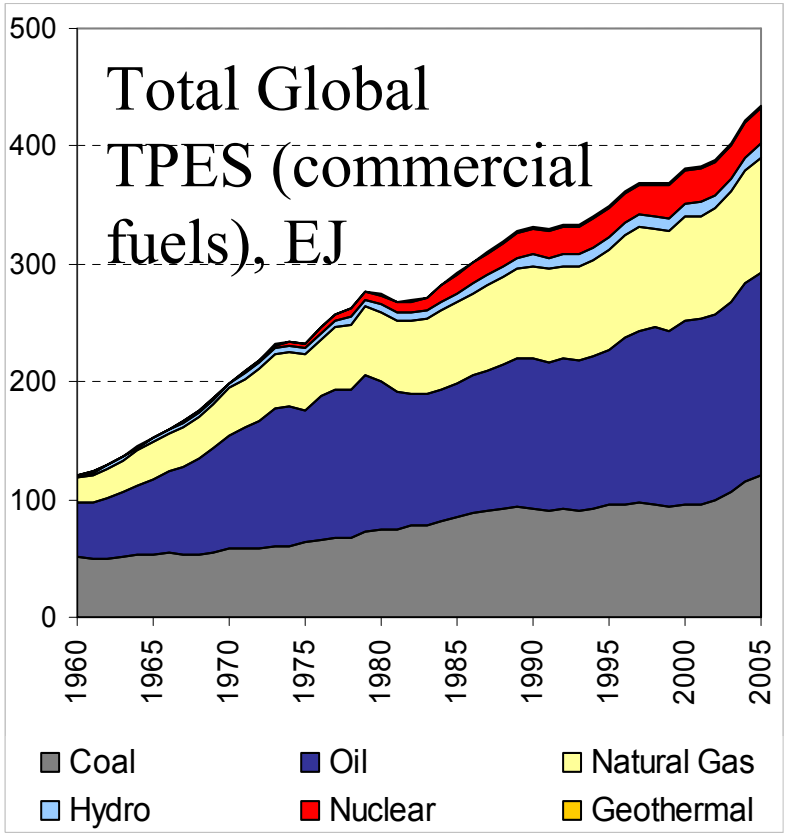
Global metabolic scale 1960-2005





Source: Krausmann et al. forthcoming, based on Krausmann et al. 2008 (Biomass), Podobnik, IEA (Fossils), USGS (minerals)

Population and population dynamics

- One key factor in the increase of global metabolic scale seems to be human population dynamics.
- This is plausible from a theoretical point of view: a certain average personal material standard of living is linked to a certain level of resource use.
- Empirically, the metabolic scale of socio-economic systems corresponds closely to their population numbers.
- If we standardize metabolic scale by population, we arrive at metabolic rates.

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2. Metabolic rates

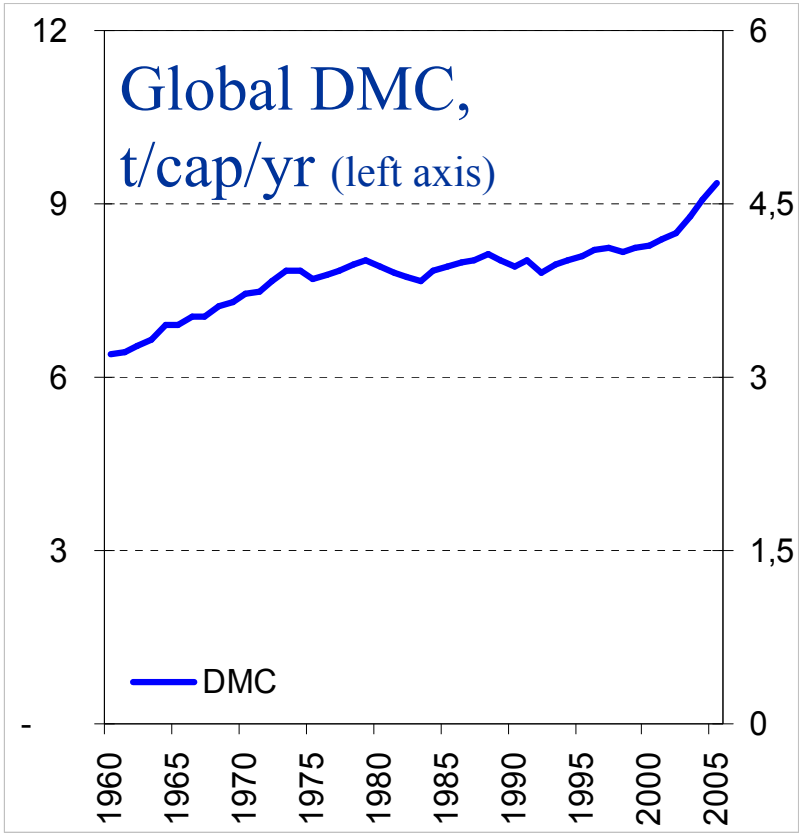
***Definition**: Metabolic rate is the metabolic scale of a socio-economic system divided by its population number = annual material / energy use per capita*

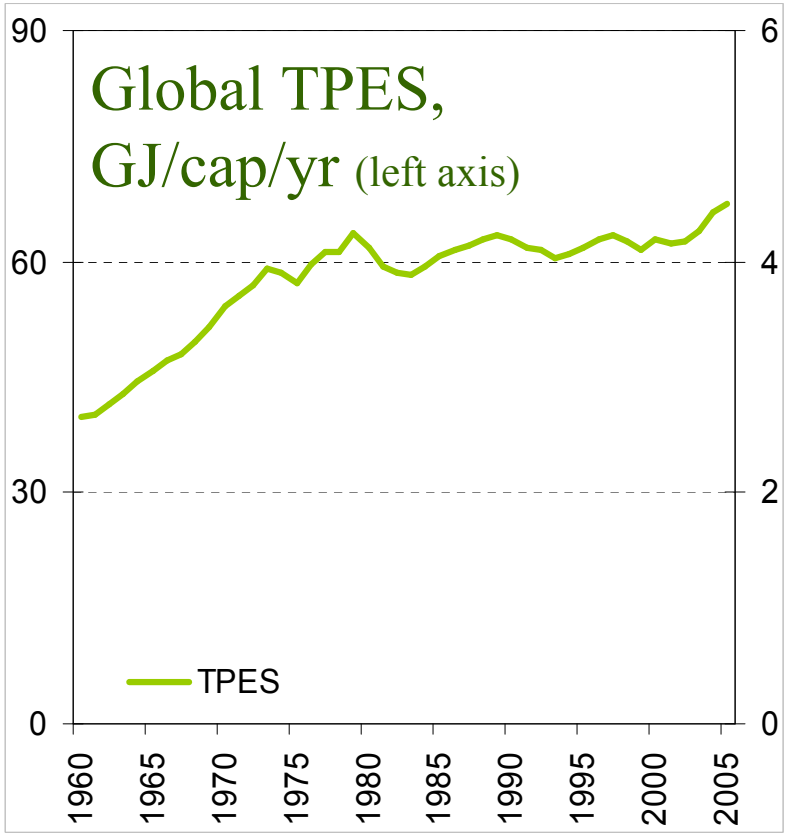
The global metabolic rate:

- Has, after an initial rise following the Second World War to the early 1970ies, remained fairly constant worldwide at about 8t/cap (DMC) and 60 GJ/cap (TPES) until the year 2000
- Despite quite substantial economic growth

About the year 2000, there seems to have started a new phase of growth with regard to metabolic rates

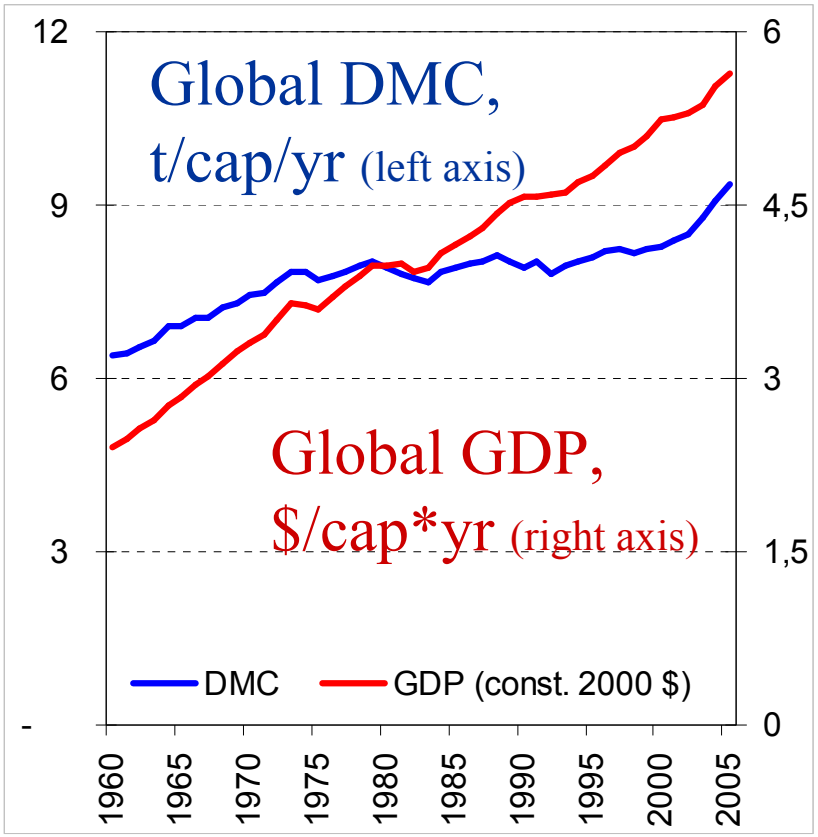
Global metabolic rates 1960-2005

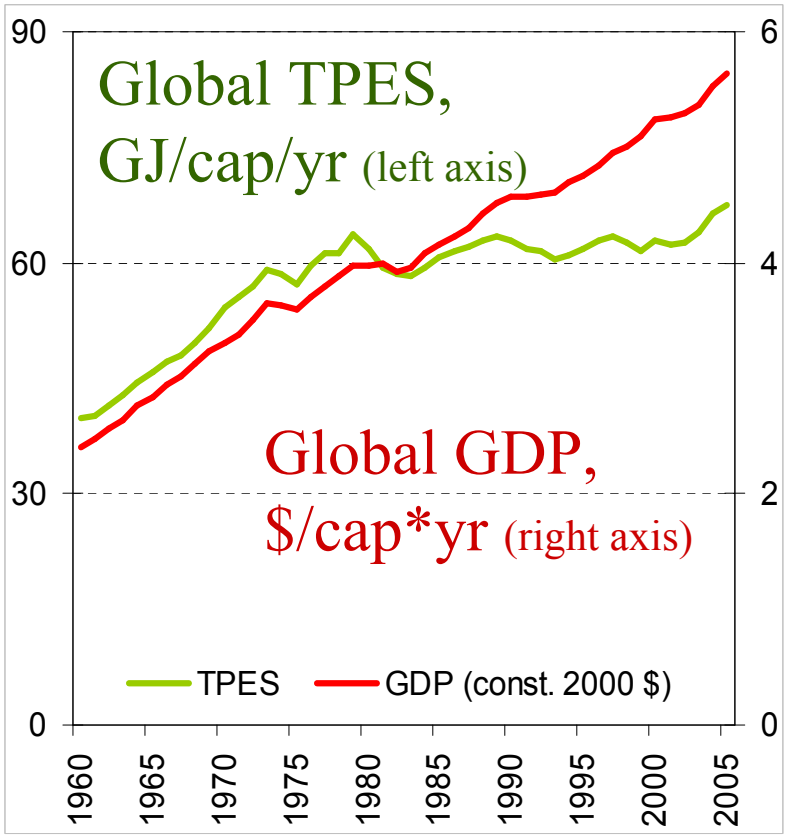




Source: Krausmann et al. forthcoming, based on Krausmann et al. 2008 (Biomass), Podobnik, IEA (Fossils), USGS (minerals)

Global metabolic rates and global GDP/capita 1960-2005





Source: Krausmann et al. forthcoming, based on Krausmann et al. 2008 (Biomass), Podobnik, IEA (Fossils), USGS (minerals)

The level of the metabolic rate depends on development and transition patterns

It is not as simple as often presupposed

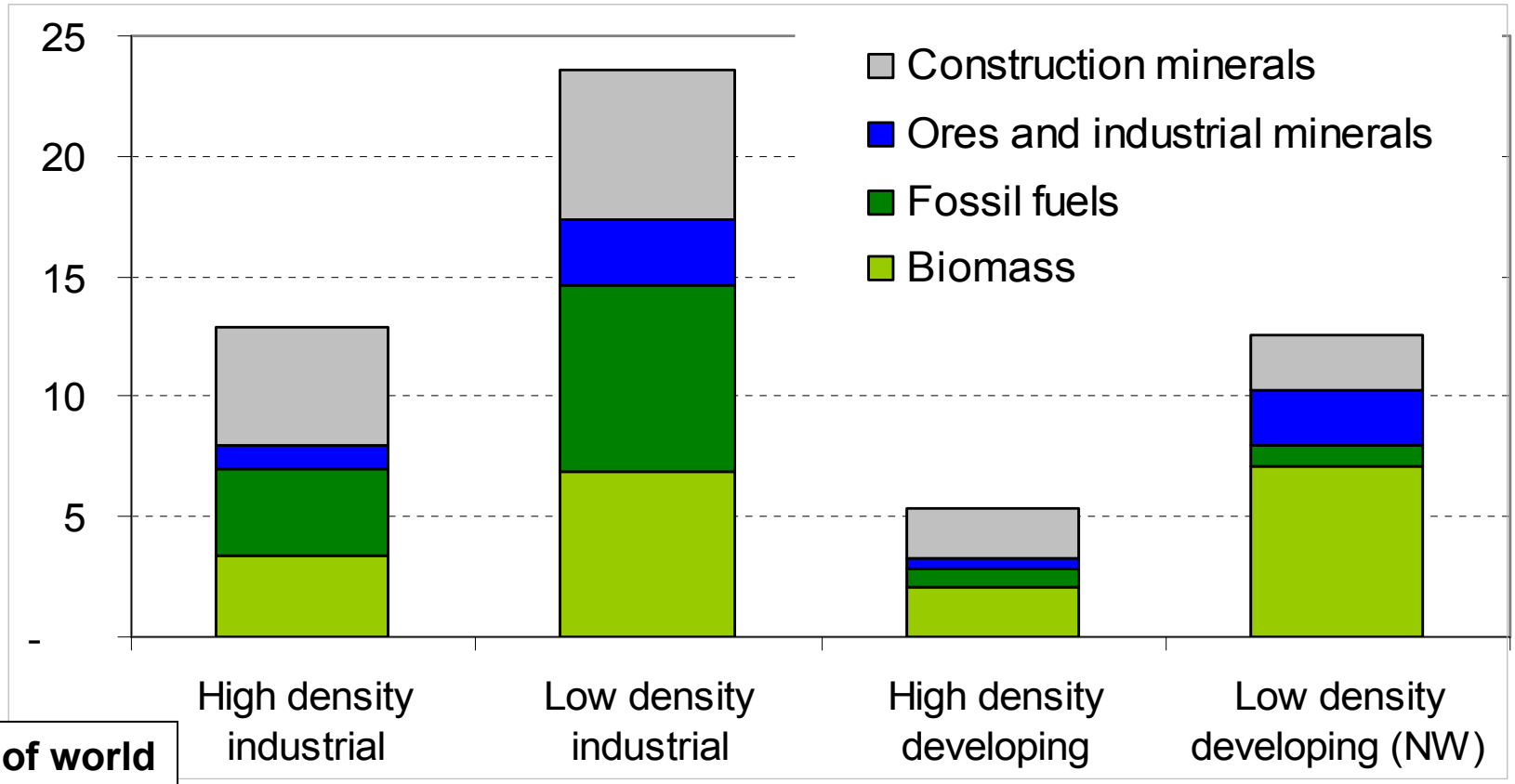
- High income industrial countries = high metabolic rates
- Lower income developing countries = lower metabolic rates

Because of (at least) 2 factors

- Resource endowment and role in the world economy (trade relations)
- Population density (infrastructures)

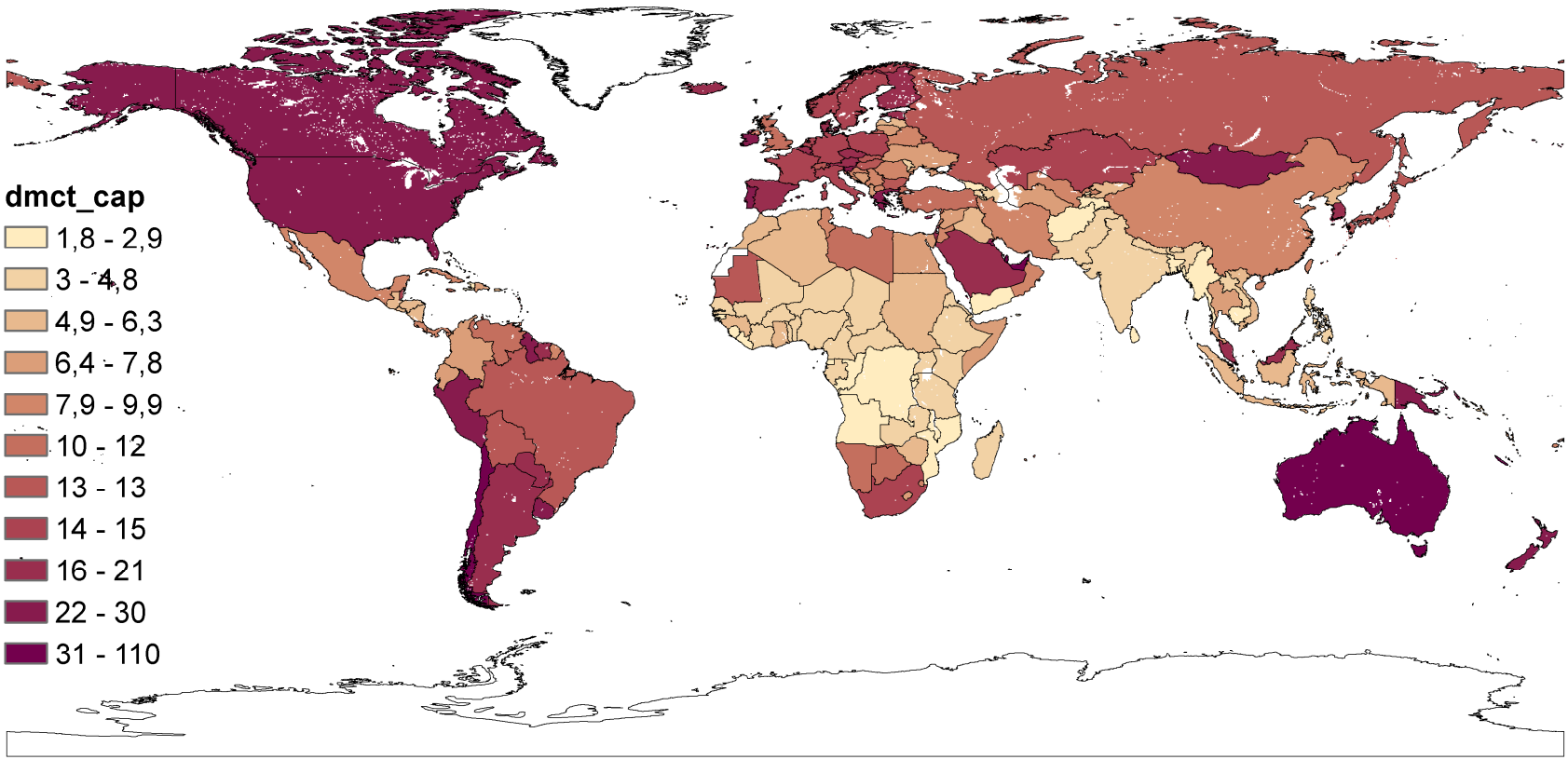
Metabolic rates by the development status and population density of countries

DMC t/cap in yr 2000



	High density industrial	Low density industrial	High density developing	Low density developing (NW)
Share of world population	**13%**	**6%**	**62%**	**6%**
Pop density	**123**	**12**	**140**	**19**

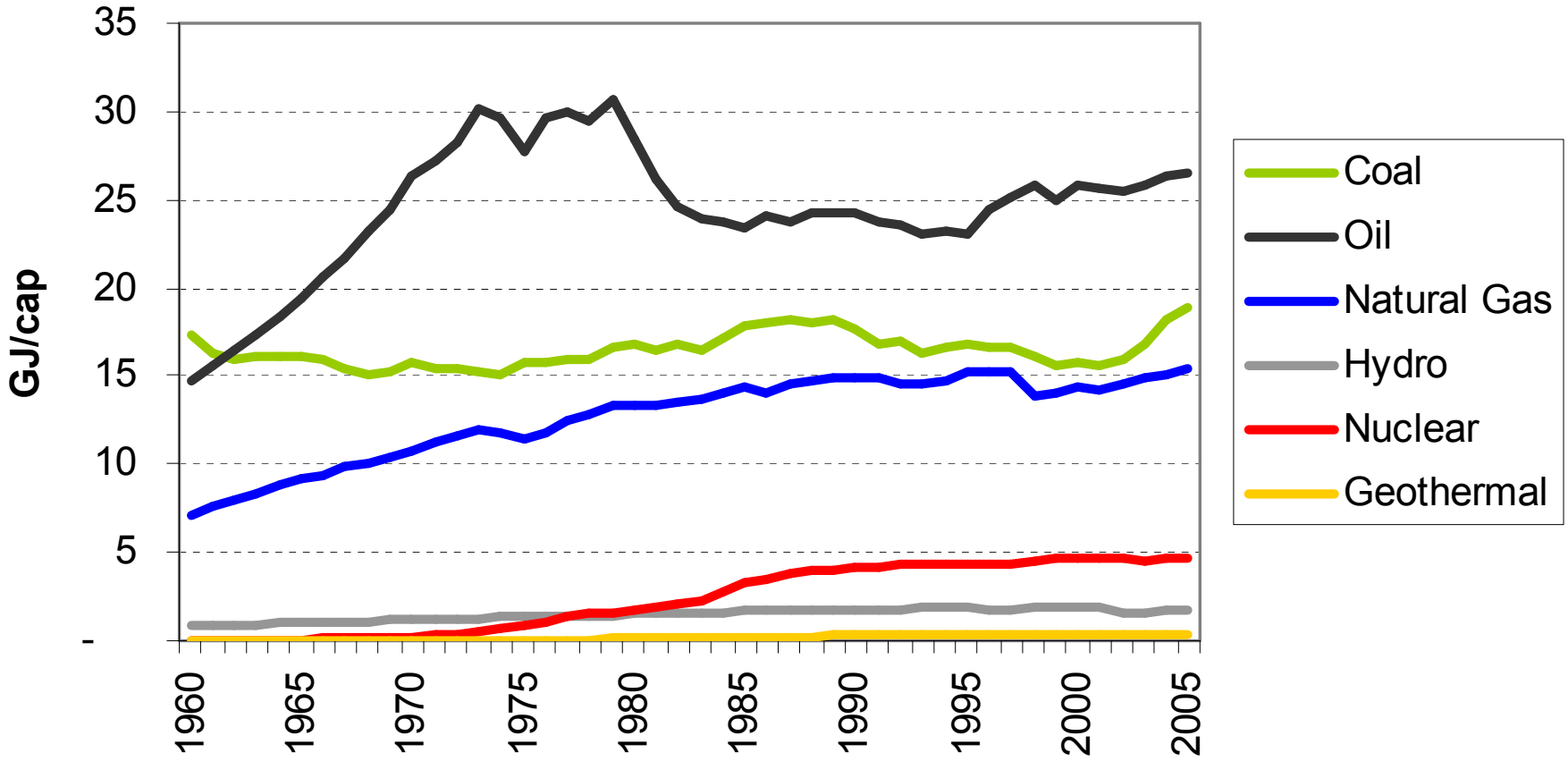
DMC per capita (in the year 2000)



global trends in metabolic rates

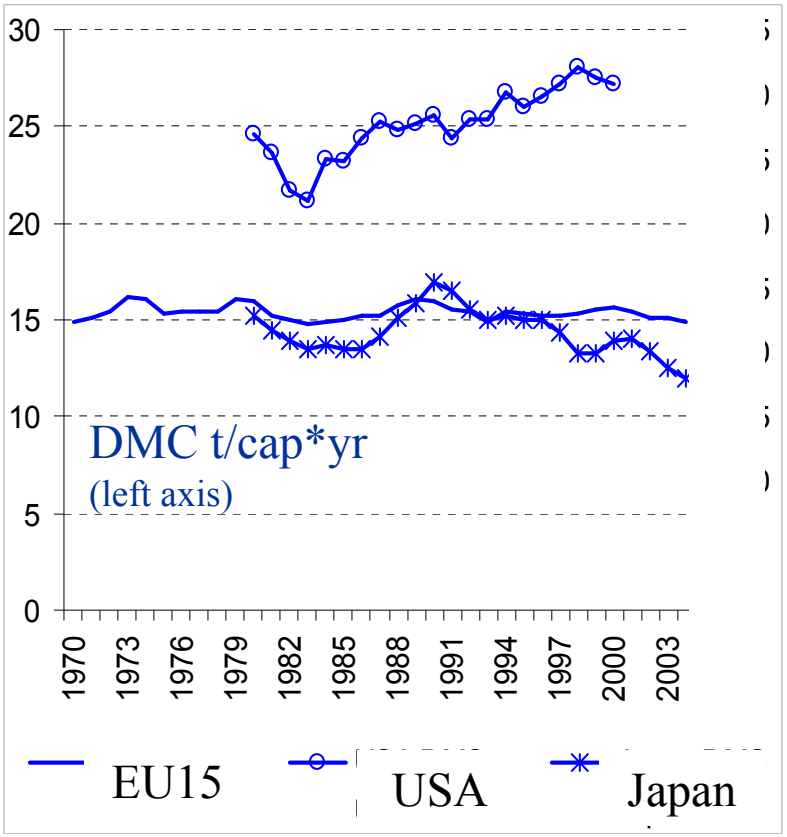
- Cultural / price shocks may have a substantial and lasting impact
- Globally stable metabolic rates in the period 1975-2000 appear to be a composite result of different trends in various world regions
  - Stability in EU 15 and Japan
  - (likely) decline in (ex) Soviet Union and Eastern Europe
  - Rise in many developing countries

The „limits to growth“-shock: Global metabolic rates (energy use / capita in GJ DEC) 1960 - 2005

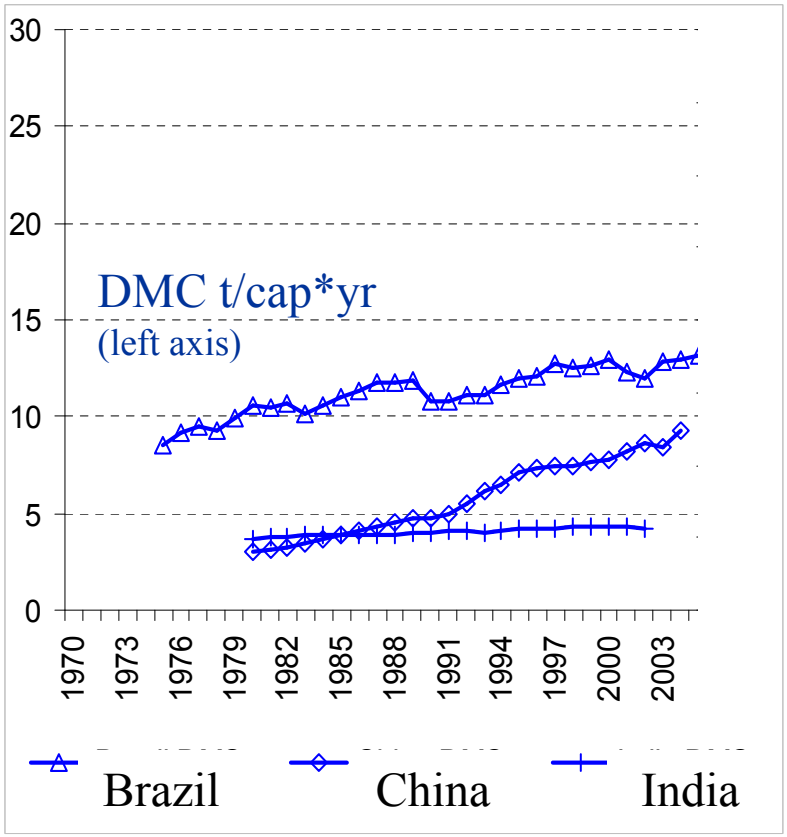


Metabolic rates (material) for selected industrial and developing countries 1970-2005

Industrial countries

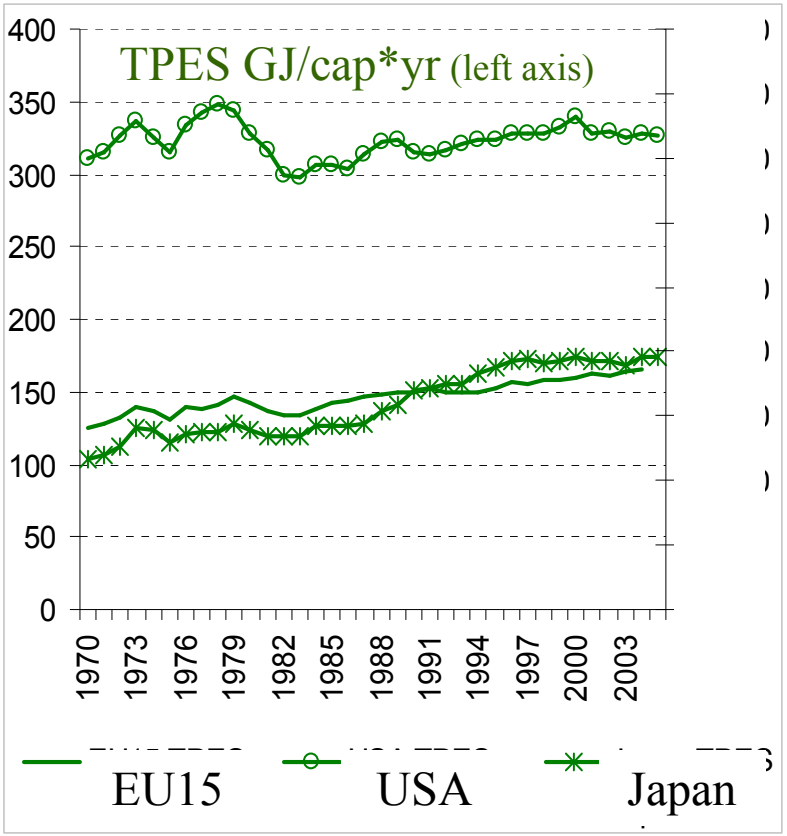


Developing countries



Metabolic rates (energy) for selected industrial and developing countries 1970-2005

Industrial countries



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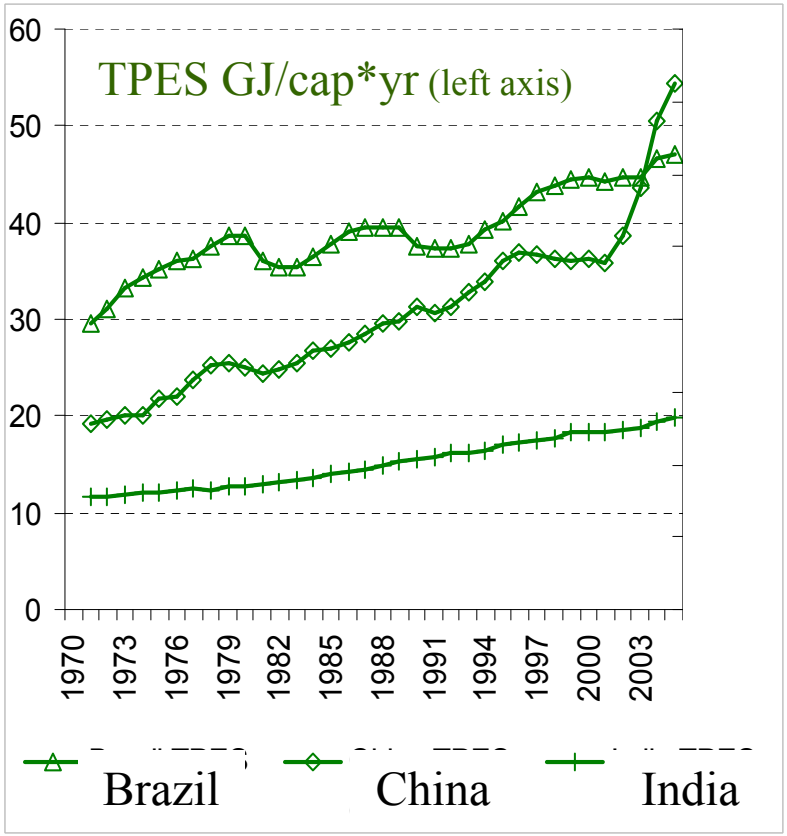

3. Decoupling

„Relative decoupling“ occurs when resource use increases at a slower pace than the economy. Rising resource productivity is a measure of relative decoupling.

Definition: *resource productivities (material productivity, MP; energy productivity, EP) of socio-economic systems are calculated as amount of income achieved (GDP) by one unit of resource use (1 t DMC, 1 GJ TPES). Thus, if income grows faster than resource use, resource productivity rises; if income grows slower, RP sinks.*

In mature industrial economies, resource productivity on the socio-economic system level typically rises by 1-2% annually. In developing countries, trends are very uneven, with RP rising or sinking.

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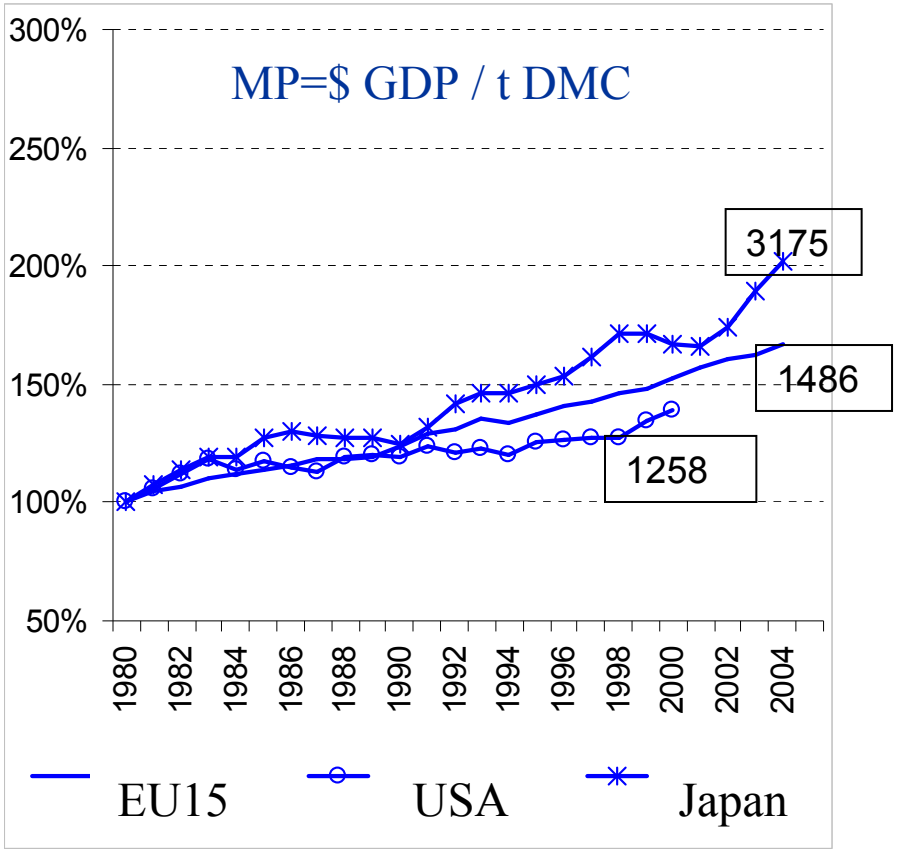
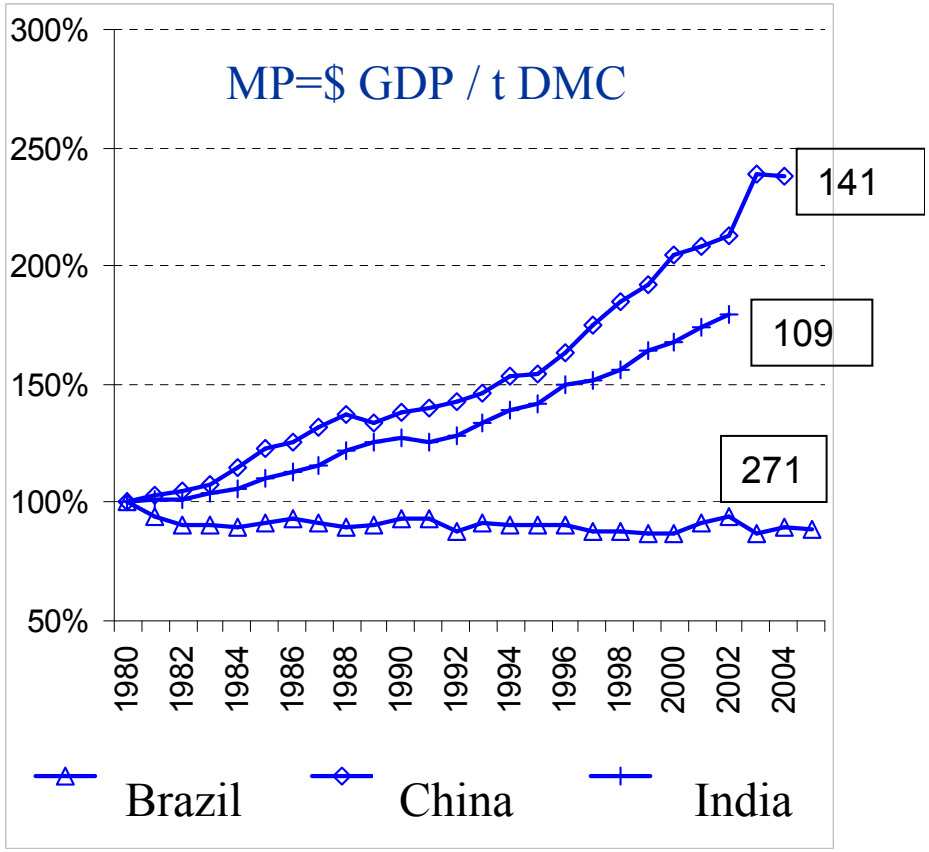
Trends in material productivity 1980-2005 (increase in %)

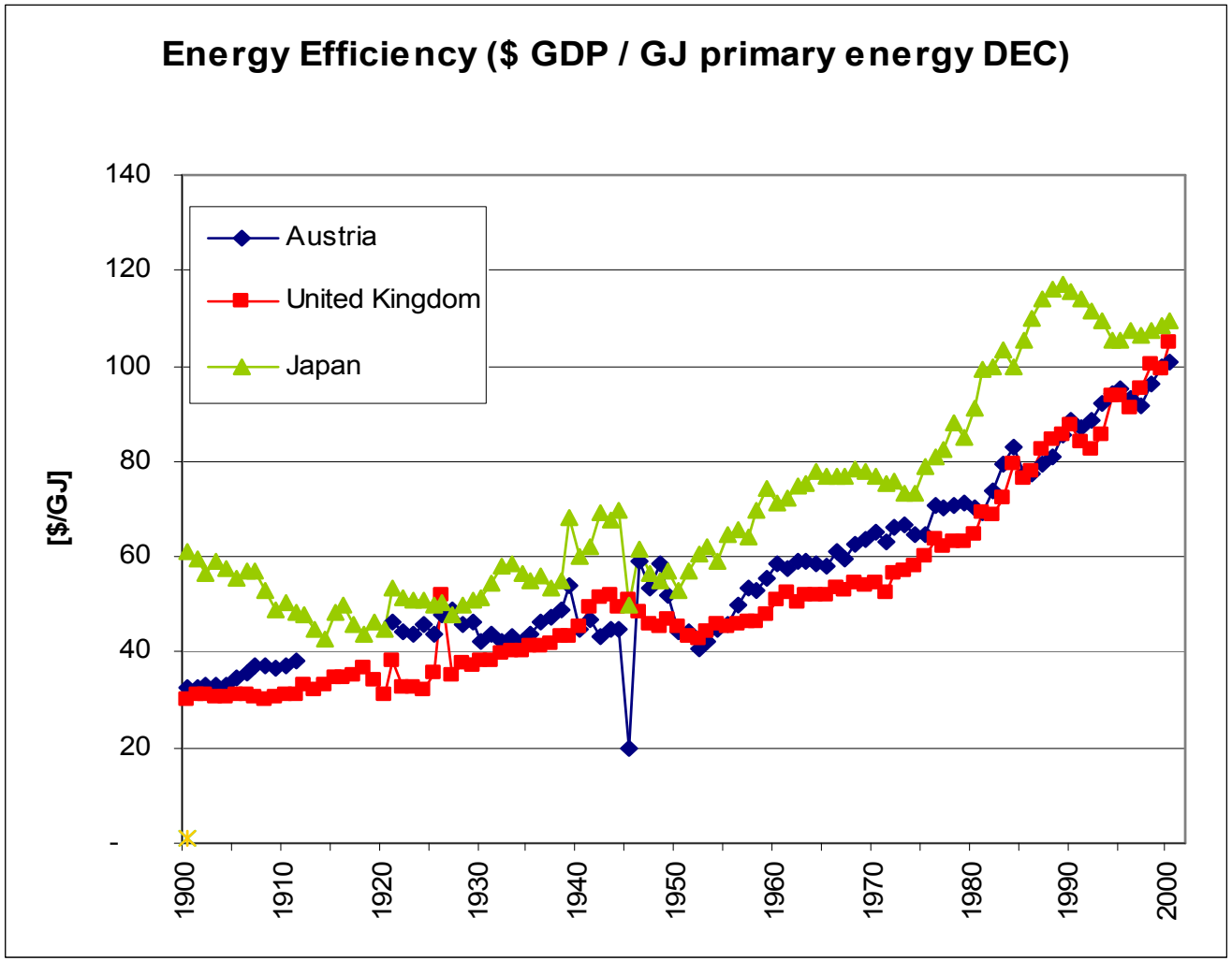
Industrial countries



Developing countries



Longterm increase in economic energy productivity (1900-2005)



Productivity increases: Average 11 % per decade, or roughly 1% annually.

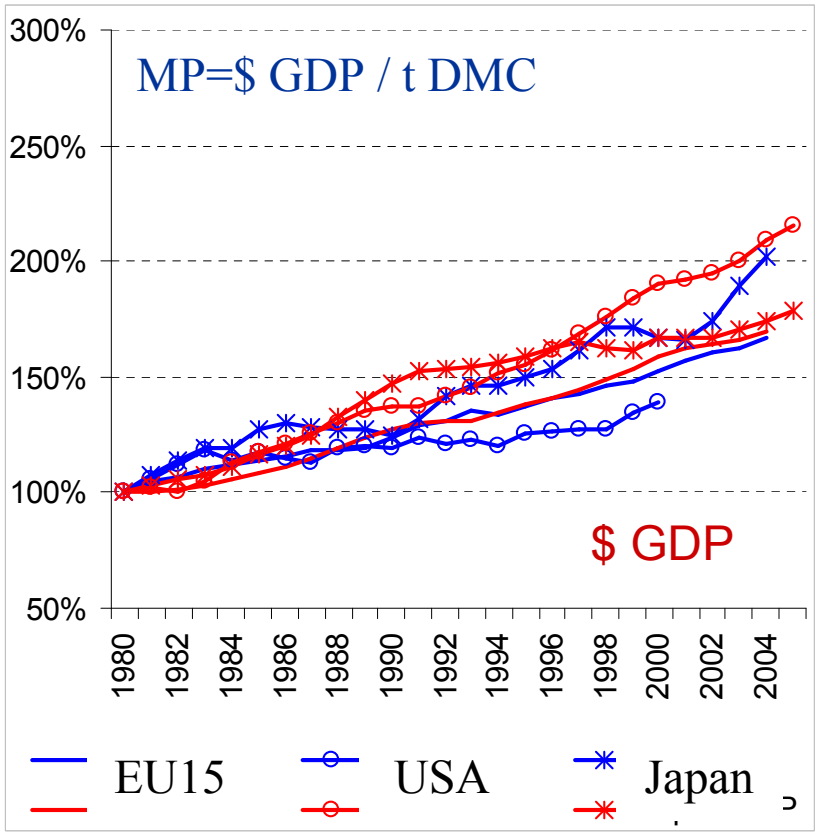
Source: Social Ecology DB

Absolute decoupling?

- Growth rates of economic resource productivity on the socio-economic system level rarely surpass growth rates of GDP.
- This probably relates to the fact that growth of resource productivity and growth of GDP mutually reinforce each other. Thus resource savings that occur because of increased resource productivity tend to be (over)compensated by accellerated economic growth. (So-called rebound effect, see Dimitropoulos 2007).
- In effect, cases of absolute decoupling on the socio-economic system level are rare. Exceptions since 1980: Japan (materials), Germany (materials and energy), UK (materials)

Trends in material productivity in relation to trends in GDP (% increase)

Industrial countries



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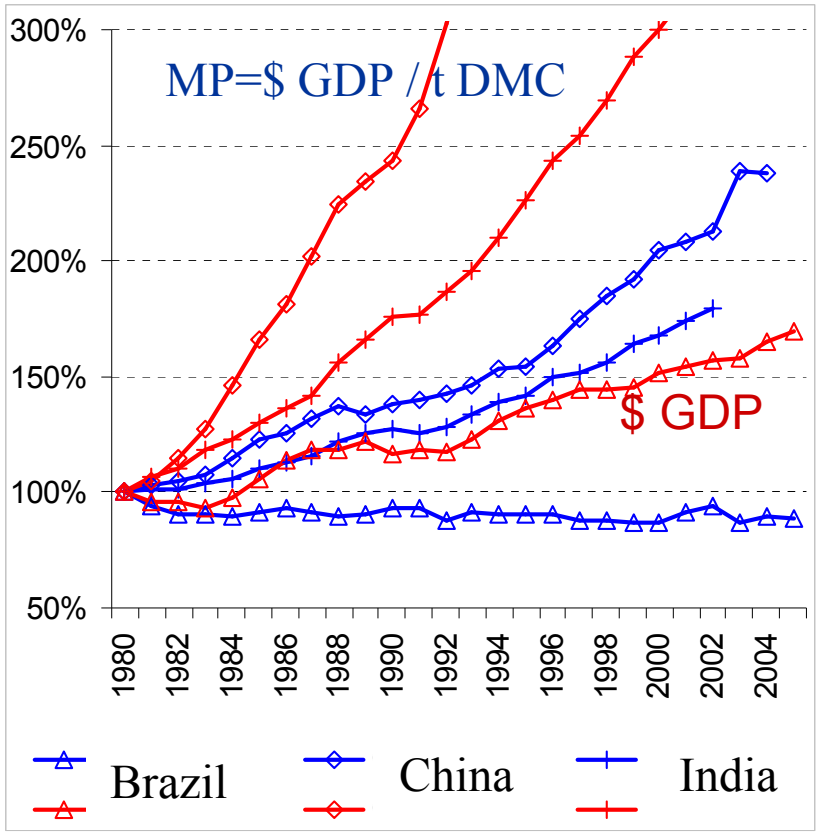
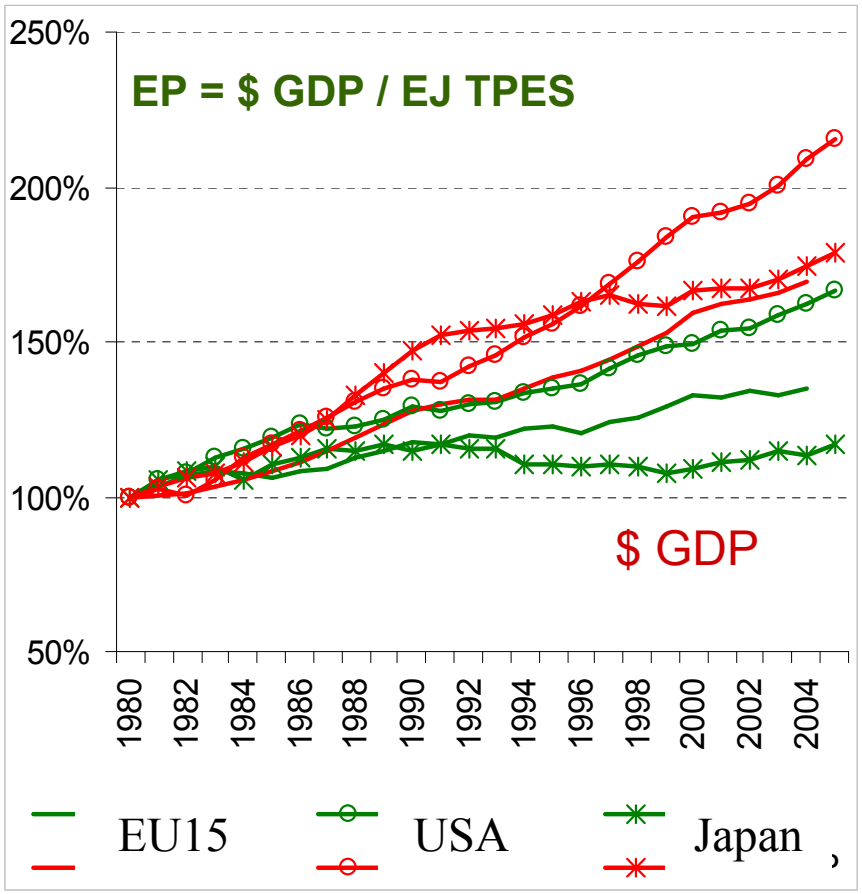


Trends in energy productivity in relation to trends in GDP (% increase)

Industrial countries



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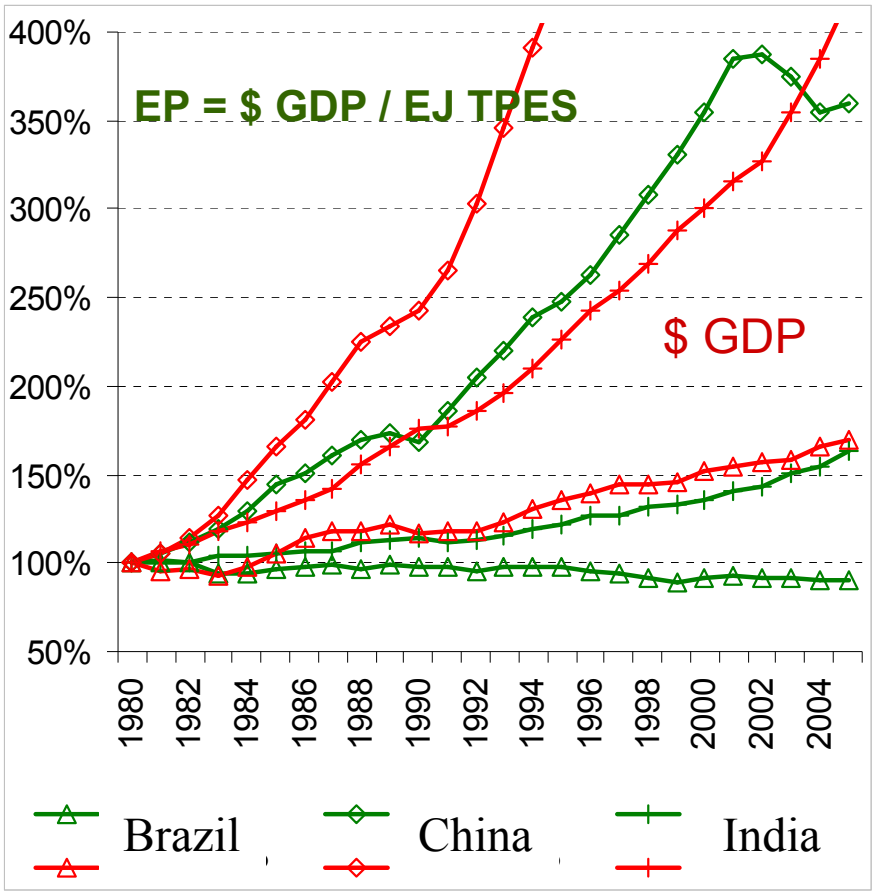
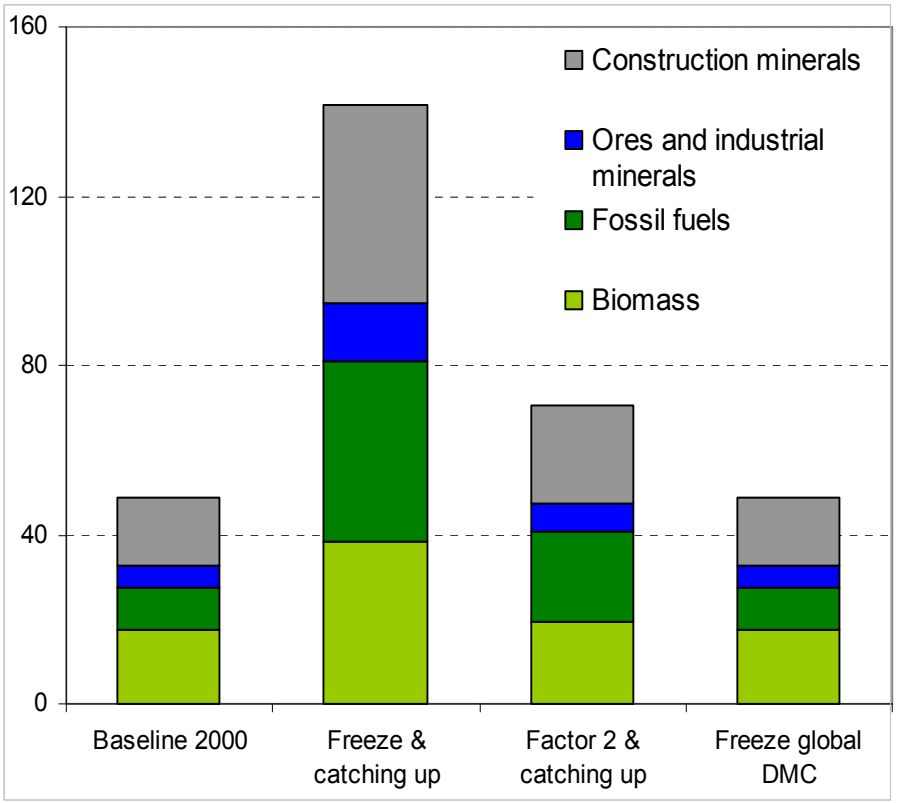


resumé

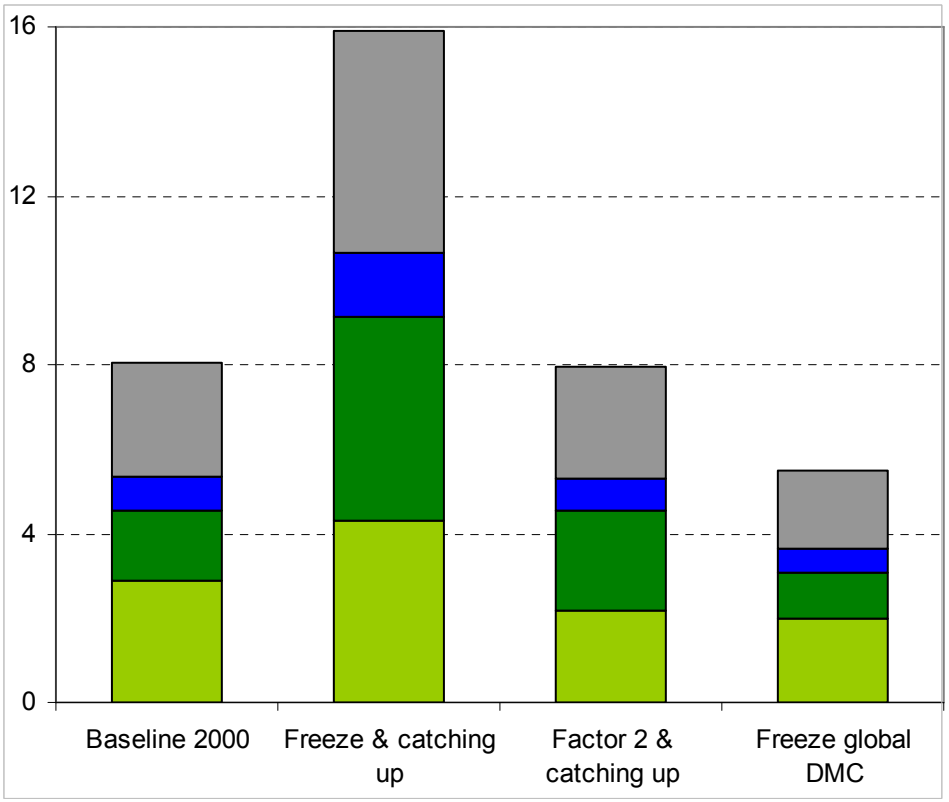
- On the global level, and on the level of socio-economic systems (countries), there is plenty of evidence on decoupling between resource use and GDP. At the rate of 1-2% annually, it is, in fact, business as usual.
- Two factors outweigh the effects of decoupling and contribute to substantial overall physical growth: population growth and transitions between metabolic rates in the course of development.
- What might convergence scenarios in the year 2050 look like?

Three forced future scenarios for 2050

Global metabolic scales in billion tonnes



Global metabolic rates in t/cap



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Scenario assumptions

(all : relation between high density/low density countries remains unchanged; population growth by UN projection)

1. **Baseline 2000 scenario**
2. **Freeze and catching up:** industrial countries maintain their metabolic rates of the year 2000, developing countries catch up to same rates
3. **Factor 2 and catching up**: industrial countries reduce their metabolic rates by factor 2, developing countries catch up
4. **Freeze global DMC:** global resource consumption by the year 2000 remains constant by 2050, industrial and developing countries settle for identical metabolic rates

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Deviation of scenarios from baseline 2000 (in indexed t/cap)

	Freeze & catching up	Factor 2 & catching up	Freeze global DMC
HDI	1,0	0,5	0,3
LDI	1,0	0,5	0,3
HDD	2,4	1,2	0,8
LDD	2,7	1,3	0,9

FIN

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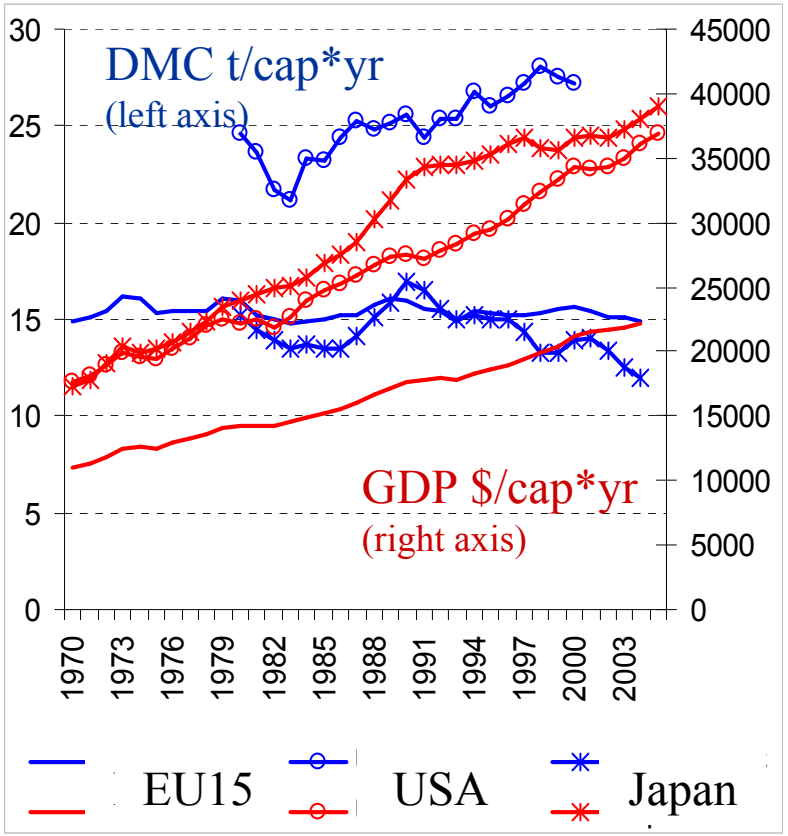
Metabolic rates (material) for selected industrial and developing countries 1970-2005, in relation to GDP / capita

Industrial countries



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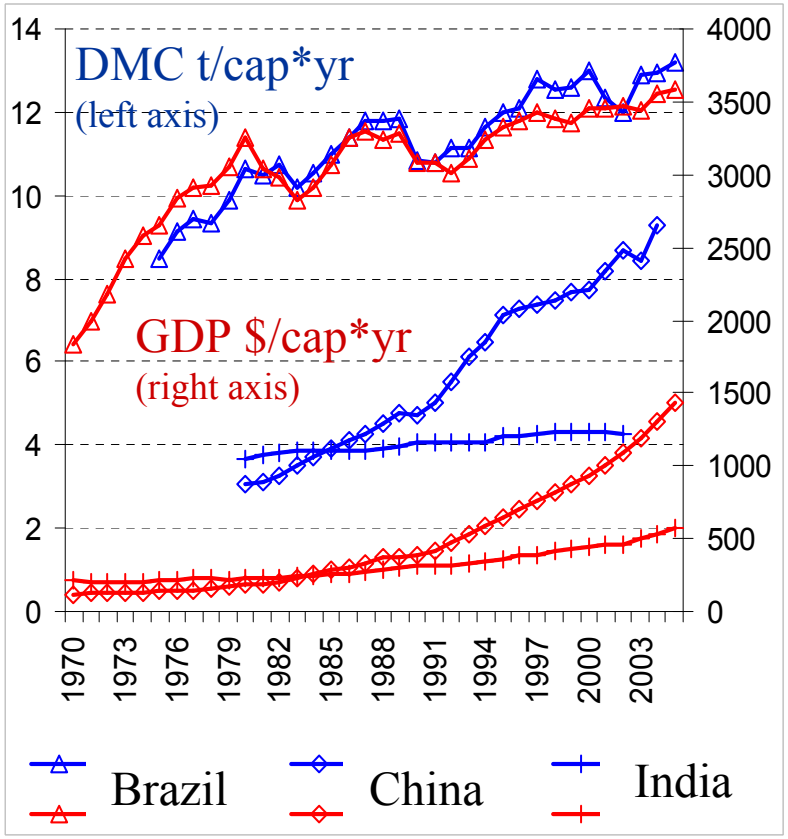
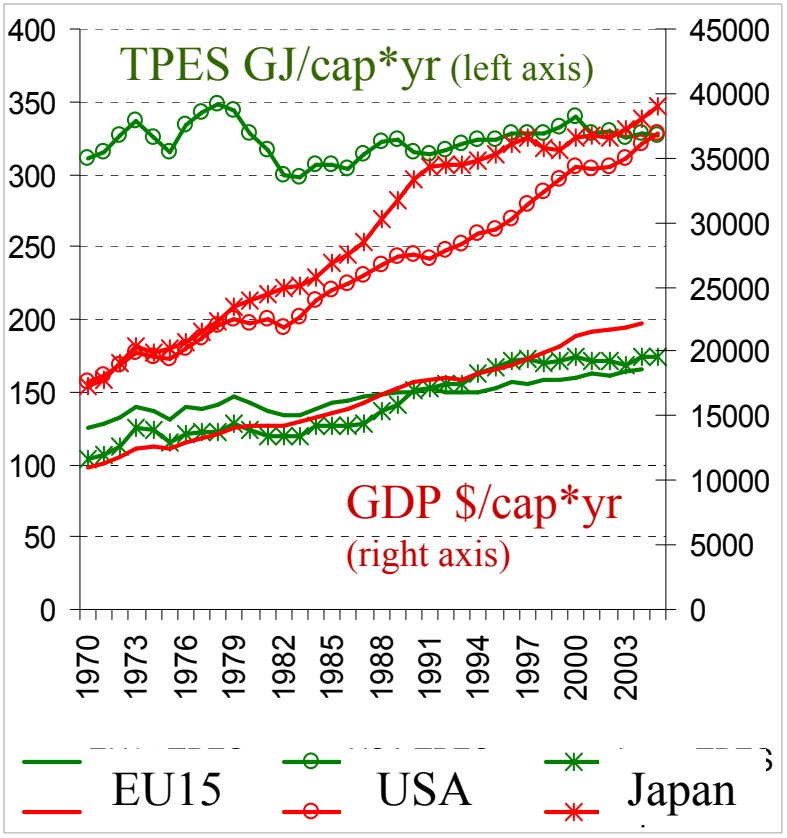


Metabolic rates (energy) for selected industrial and developing countries 1970-2005, in relation to GDP / capita

Industrial countries



Developing countries